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Jackson

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(54) **METHOD FOR IMPLANTING AN ELONGATED IMPLANT ALONG A SPINE OF A PATIENT**

(71) Applicant: **Roger P. Jackson**, Prairie Village, KS (US)

(72) Inventor: **Roger P. Jackson**, Prairie Village, KS (US)

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(60) Continuation of application No. 13/573,660, filed on Oct. 2, 2012, which is a continuation of application No. 13/374,932, filed on Jan. 24, 2012, now Pat. No. 8,377,067, which is a continuation of application No.

(Continued)

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A61B 17/70 (2006.01)
A61B 17/56 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/7088*** (2013.01); ***A61B 17/7001*** (2013.01); ***A61B 17/7002*** (2013.01); ***A61B 17/7032*** (2013.01); ***A61B 17/7035*** (2013.01); ***A61B 17/7037*** (2013.01); ***A61B 17/7085*** (2013.01); ***A61B 17/7091*** (2013.01); *A61B 17/7011* (2013.01); *A61B 2017/564* (2013.01)

(58) **Field of Classification Search**
CPC A61B 17/7085; A61B 17/7091; A61B 17/7088
USPC ..... 606/250–279, 86 A, 104, 99, 300, 301, 606/323, 914, 916, 319
See application file for complete search history.

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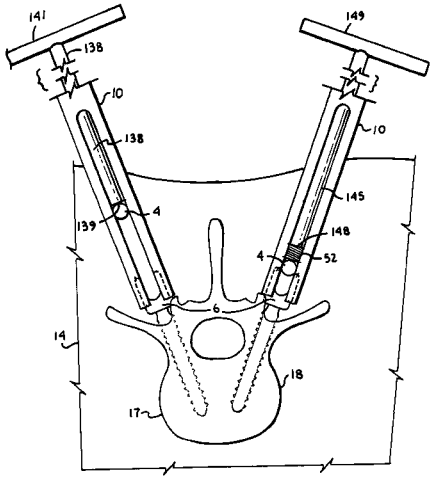
Primary Examiner — Pedro Philogene
(74) *Attorney, Agent, or Firm* — Polsinelli PC

(57) **ABSTRACT**

A tool set for implanting a rod in a human spine in conjunction with bone screws. The tool set includes a pair of end guide tools that receive opposite ends of the rod in channels and under manipulation by a surgeon facilitate transport of the rod toward the bone screws attached to the guide tools. Intermediate guide tools having guiding pass through slots are utilized to guide intermediate locations along the rod toward associated bone screws. An attachment structure operably connects the guide tools to the bone screws. The guide tools each include a lower guide and advancement structure to allow a closure top with mating structure to be rotated and driven downward against the rod and to cooperate with similar structure in the bone screw to seat and lock the rod therein. A method utilizing the tool set allows a surgeon to percutaneously implant the rod in the patient.

24 Claims, 13 Drawing Sheets



Related U.S. Application Data

12/584,413, filed on Sep. 4, 2009, now Pat. No. 8,100,915, which is a continuation of application No. 12/220,185, filed on Jul. 22, 2008, now Pat. No. 8,162,948, which is a division of application No. 10/789,149, filed on Feb. 27, 2004, now Pat. No. 7,160,300.

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Fig.1.

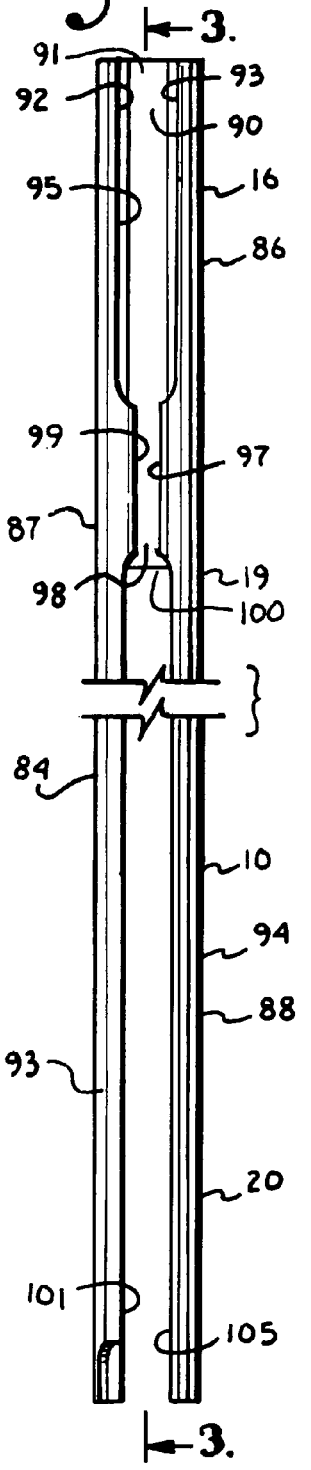


Fig.2.

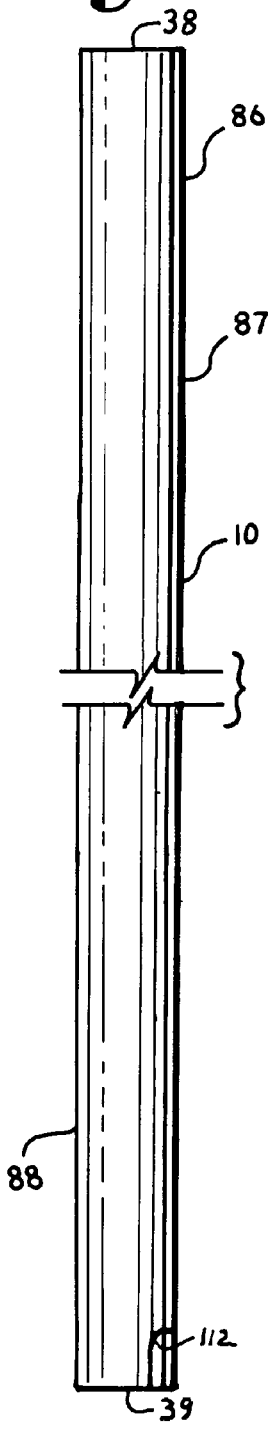


Fig.3.

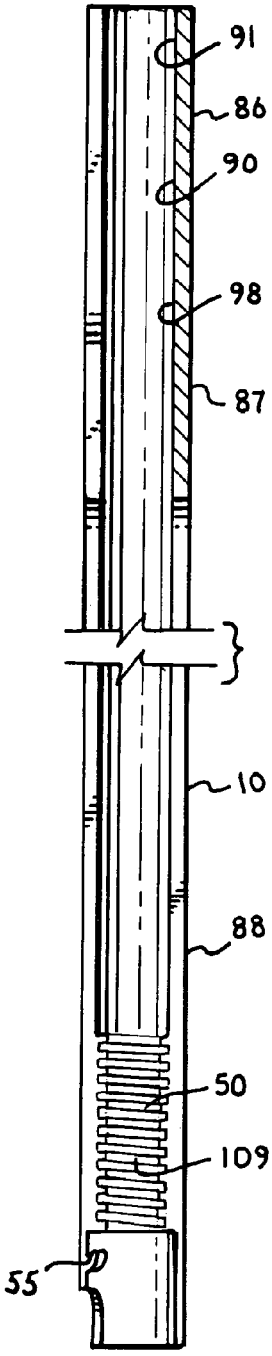


Fig.4.

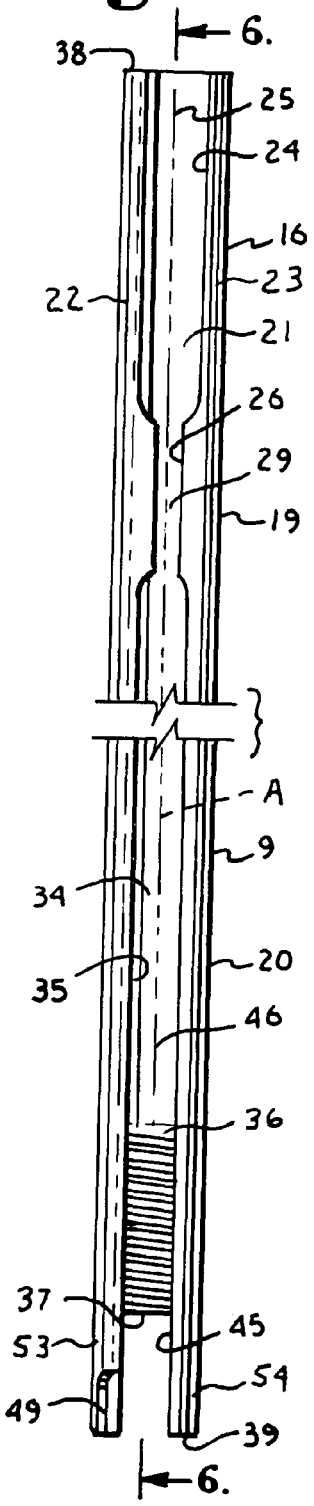


Fig.5.

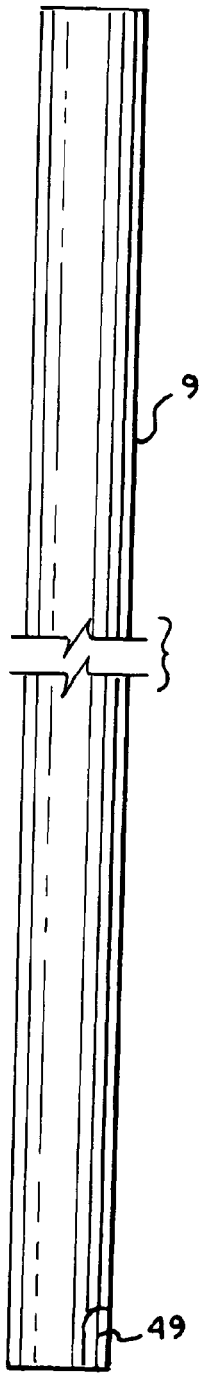
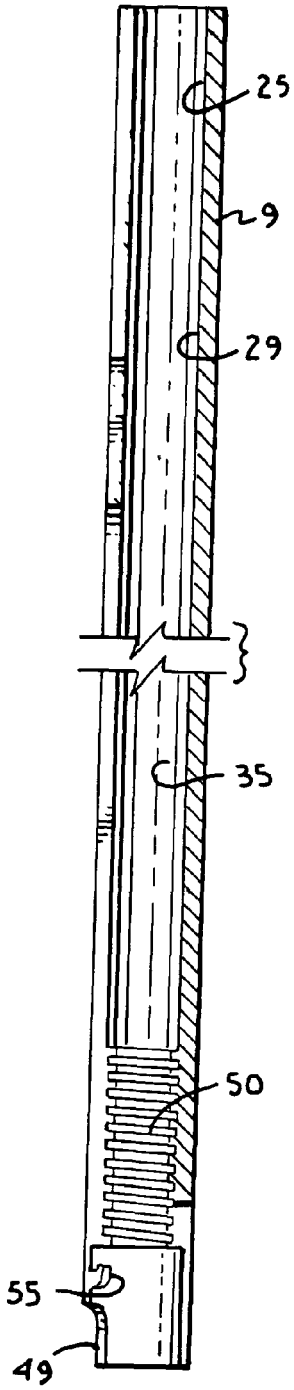
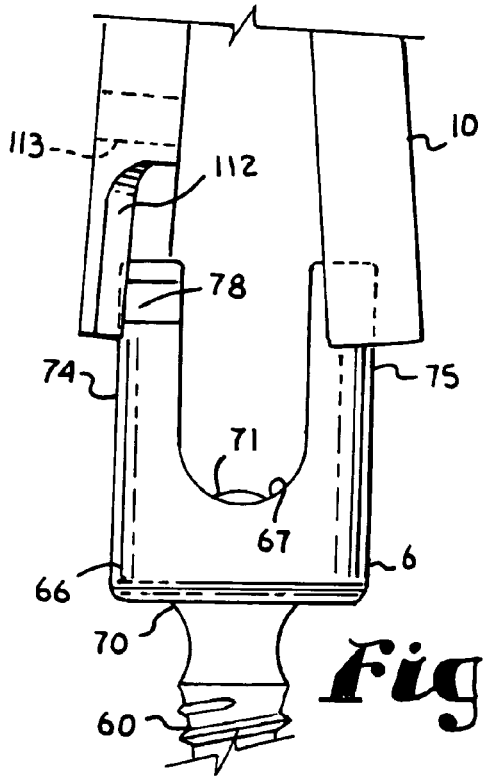


Fig.6.





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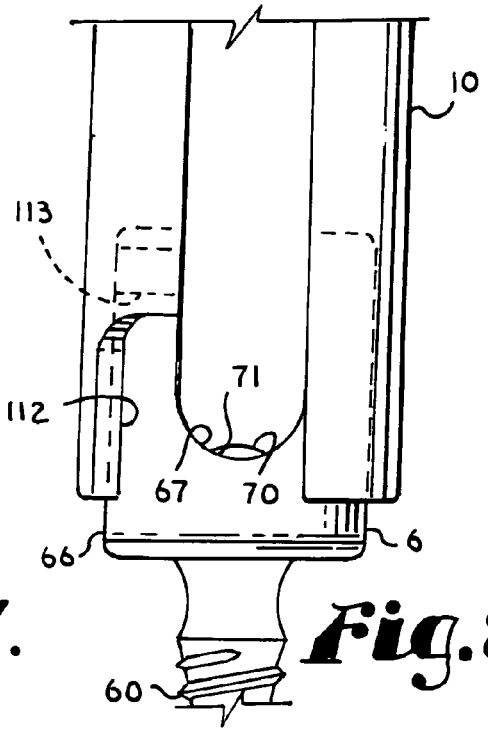
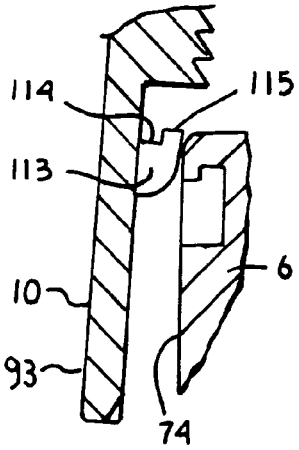


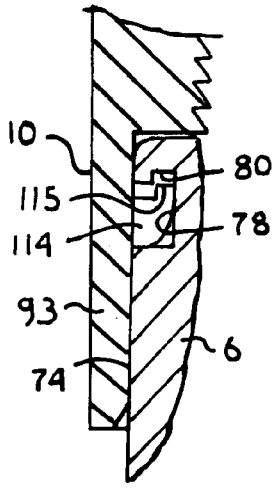
Fig.8.

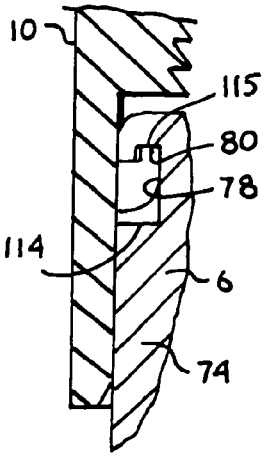
Fig.9.

Fig.10.

Fig.11.







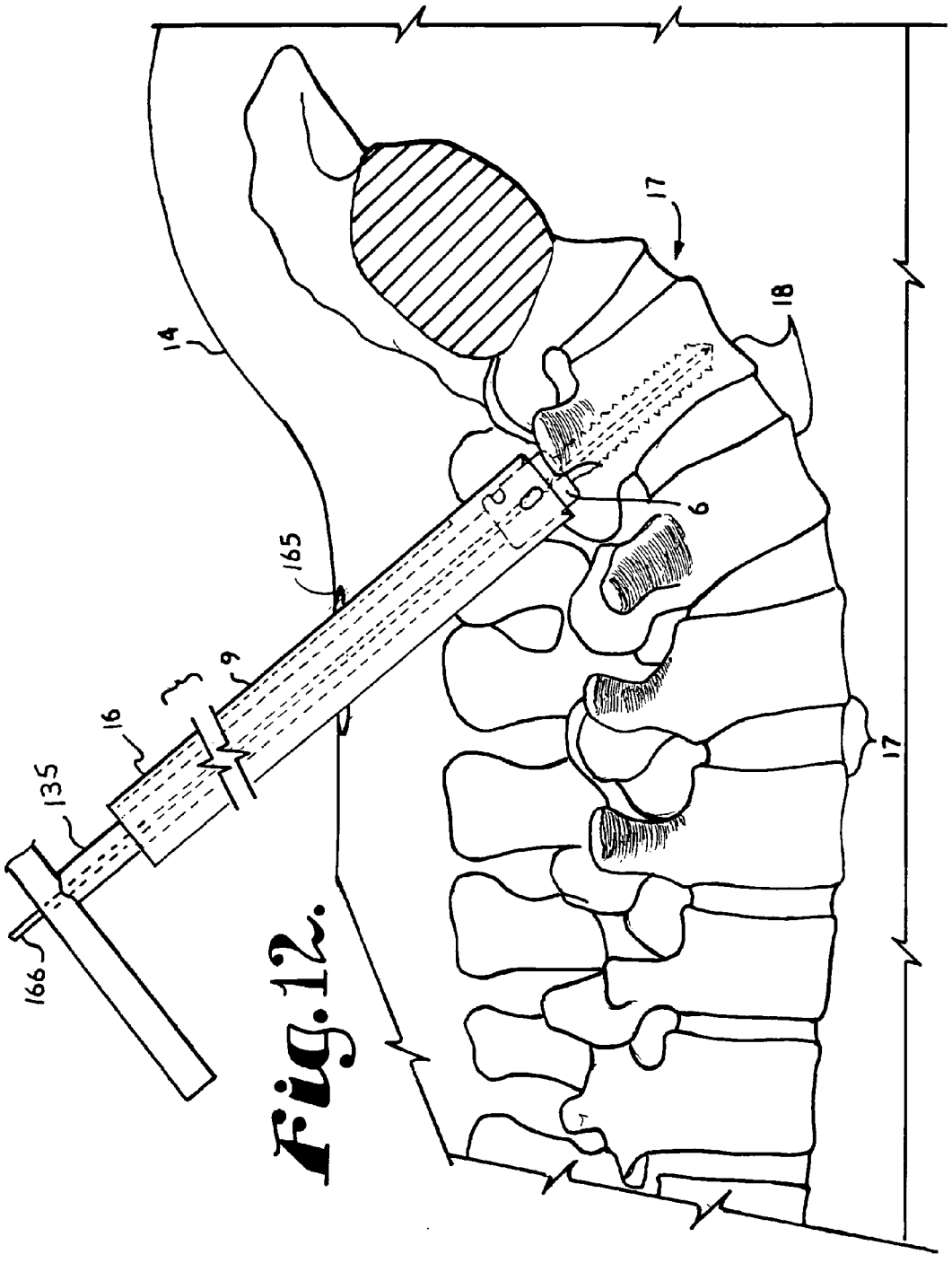
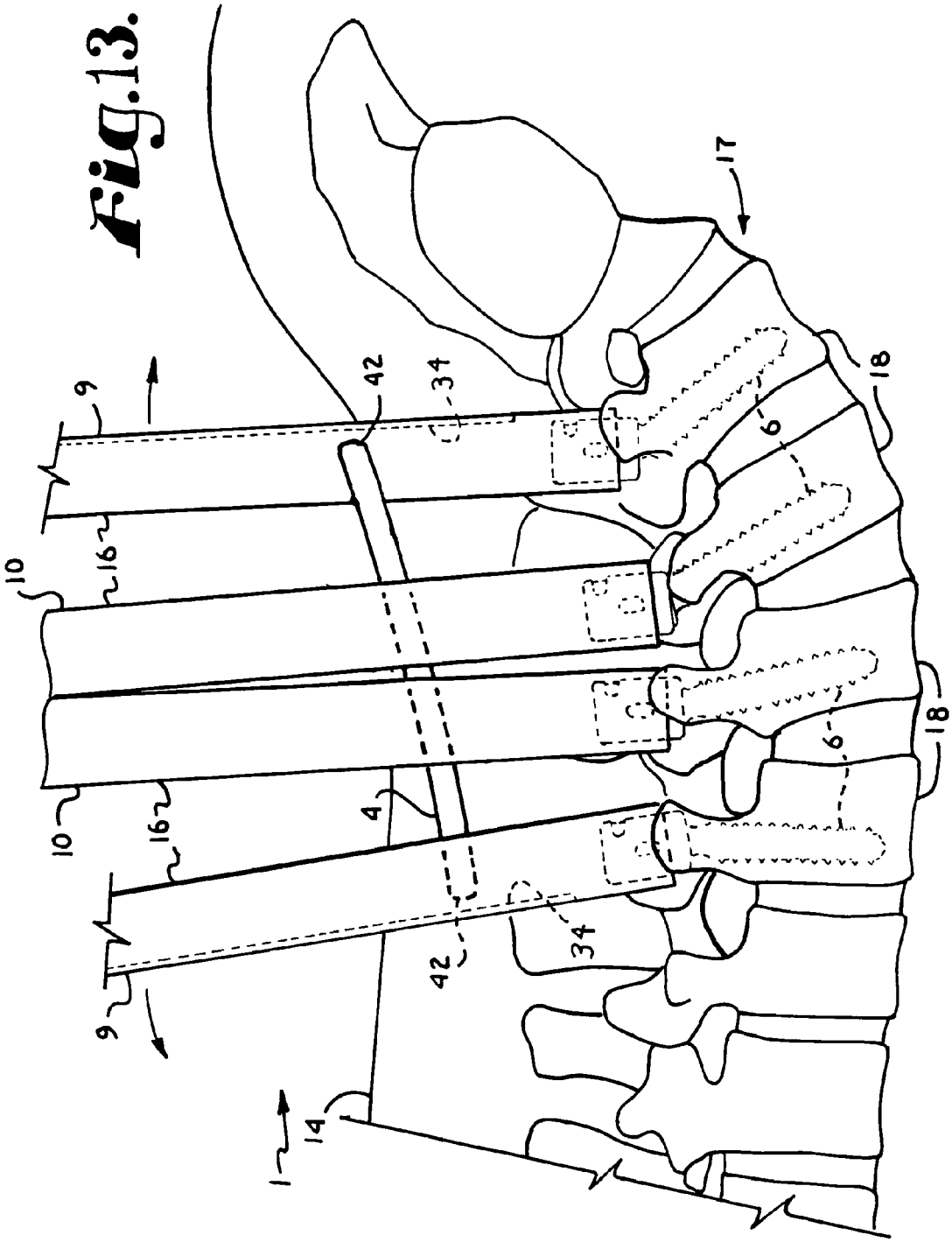
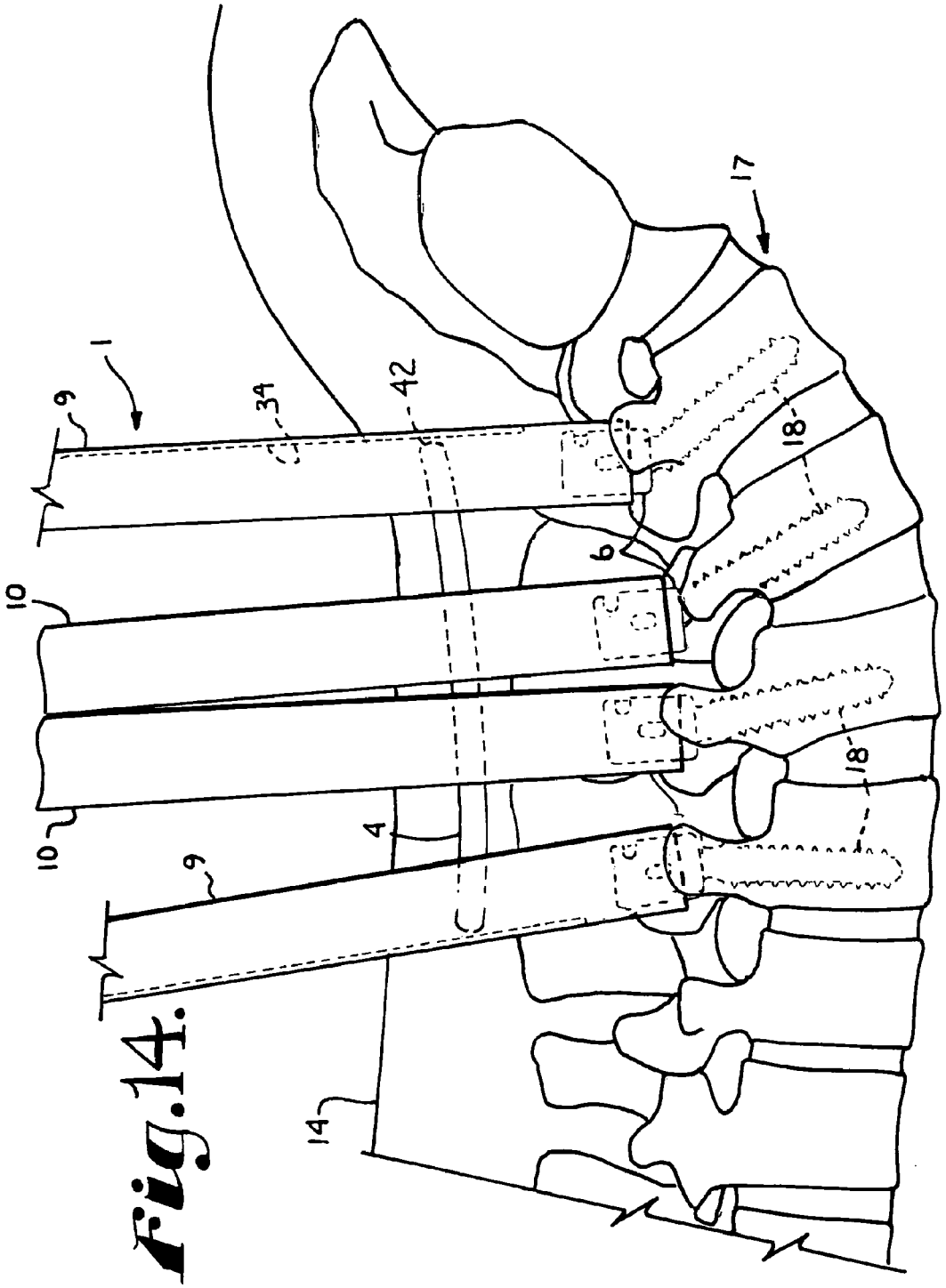


Fig. 12.

Fig.13.





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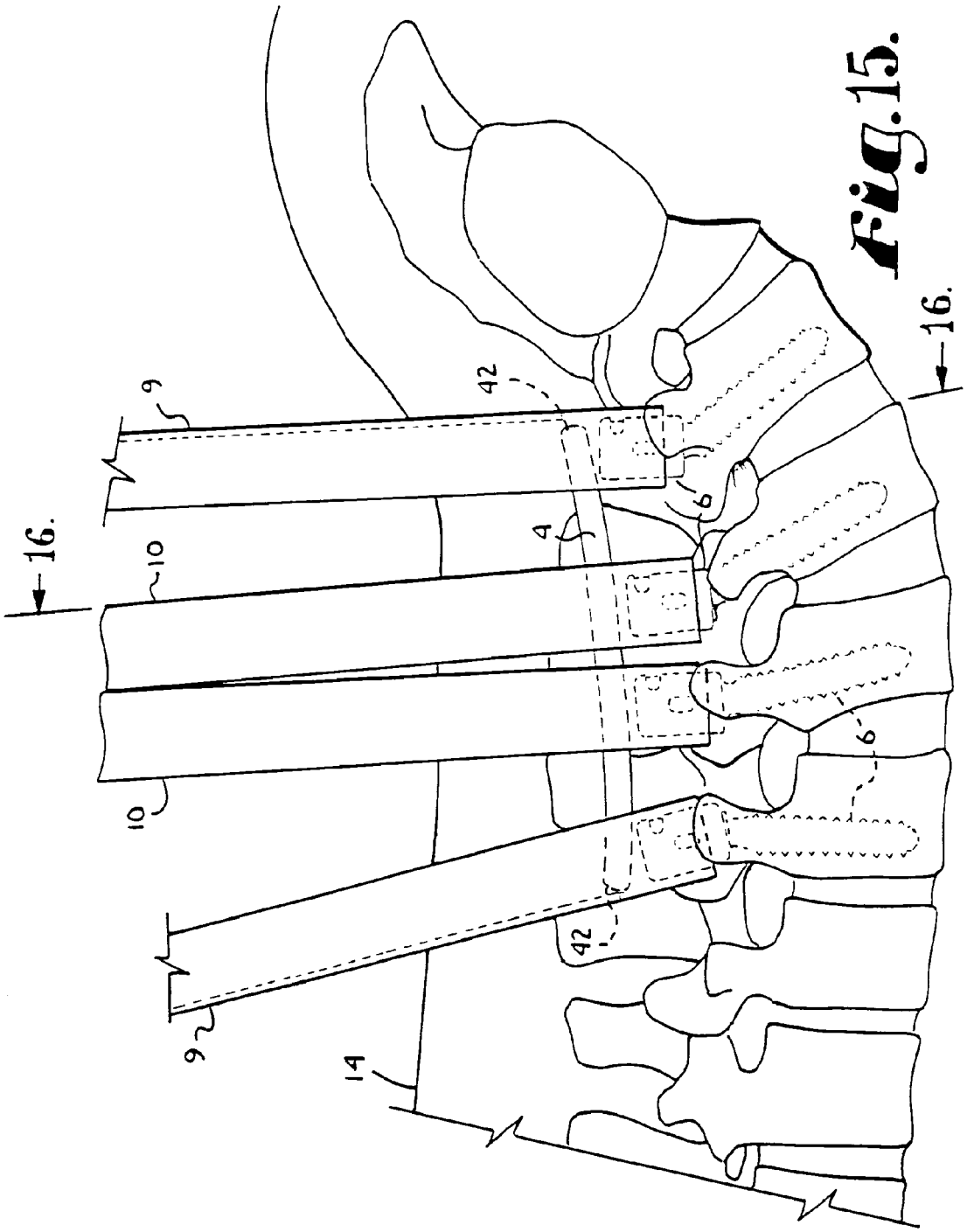

Fig. 15.

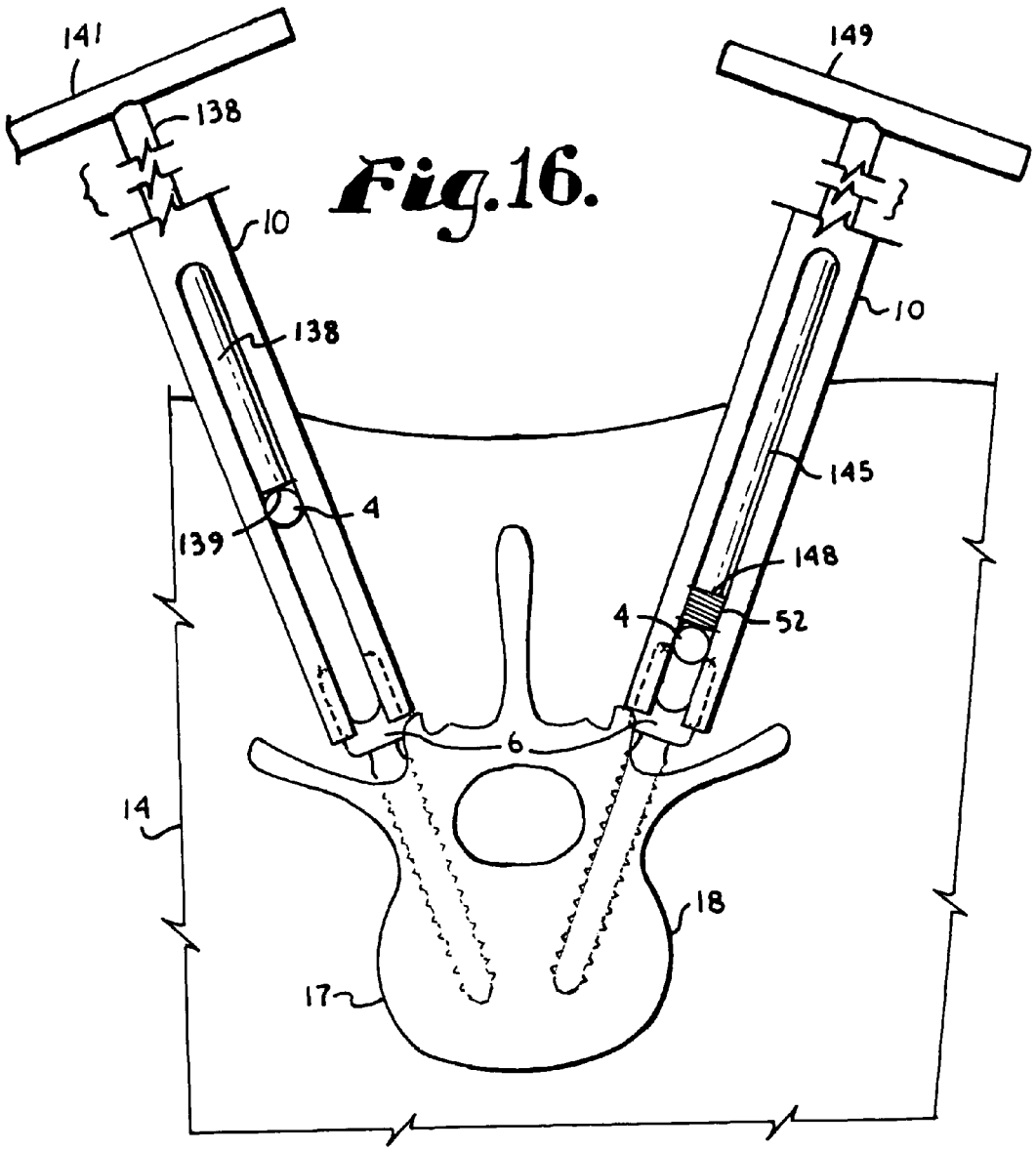

Fig.16.

Fig.17.

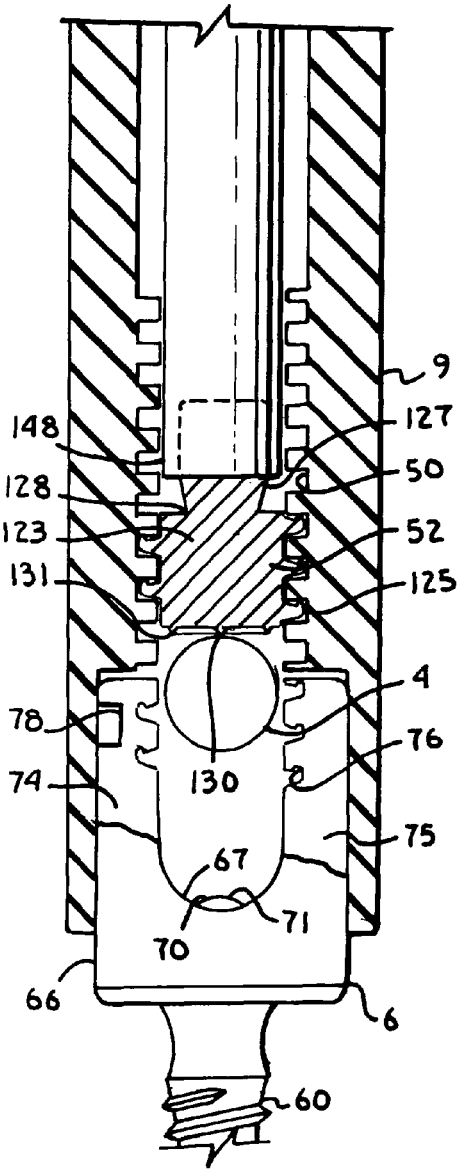
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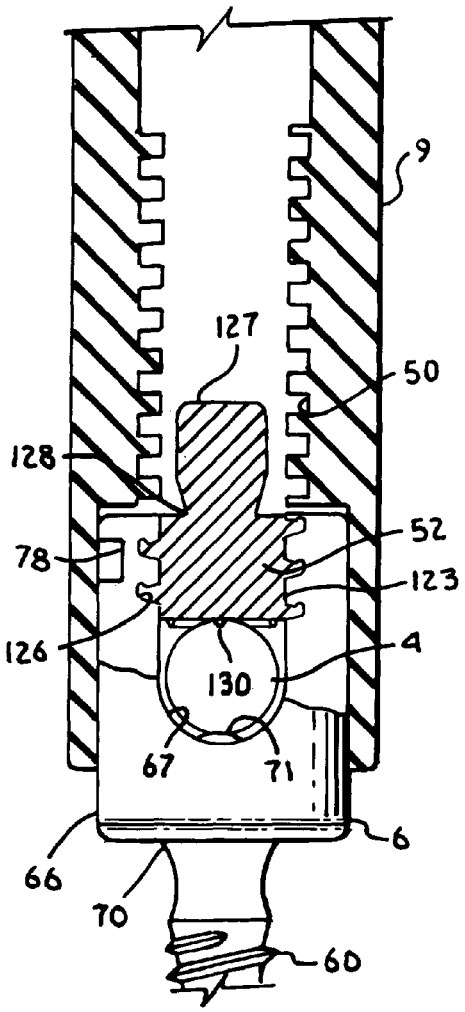
Fig.18.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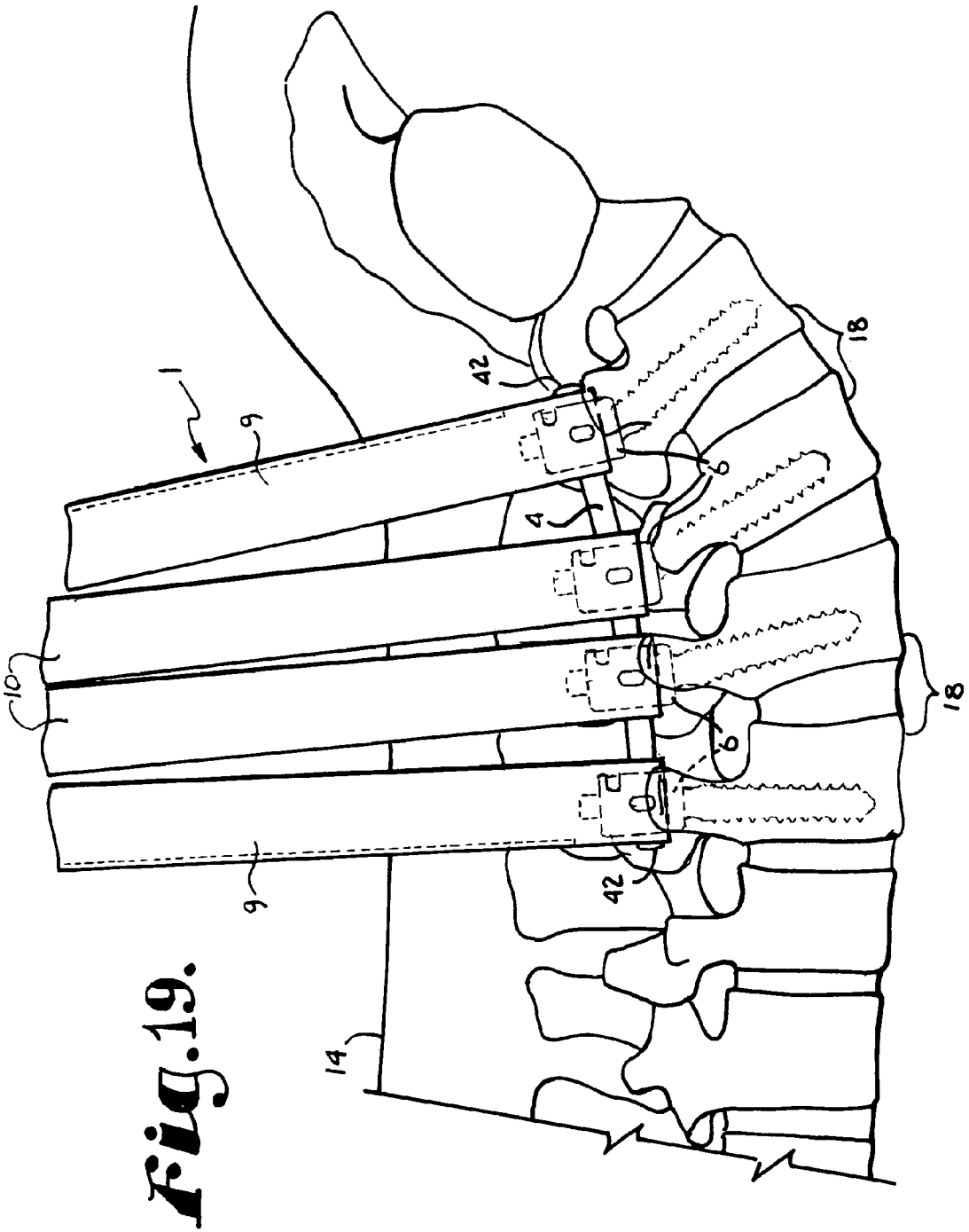


Fig.19.

Fig. 20.

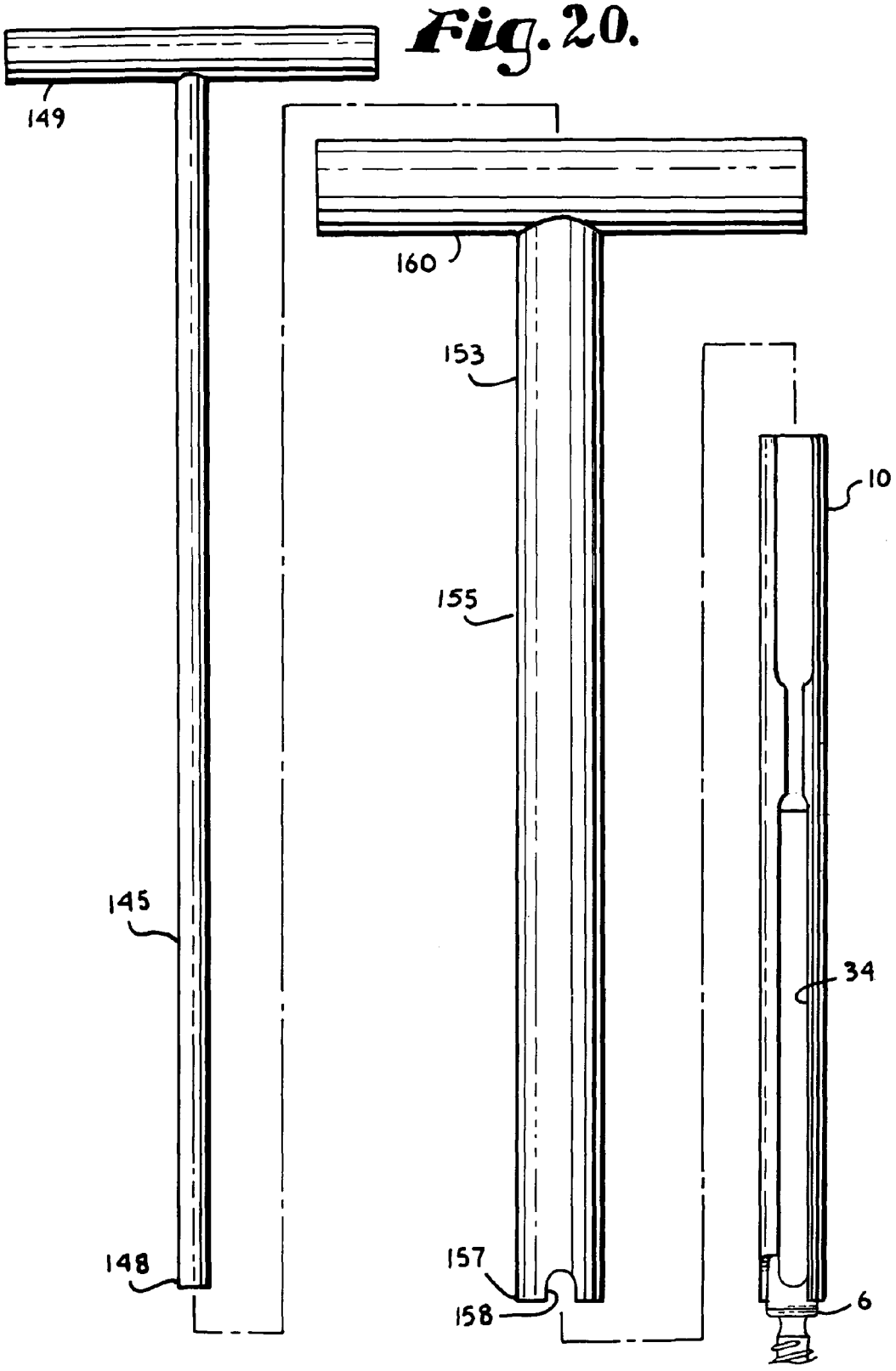
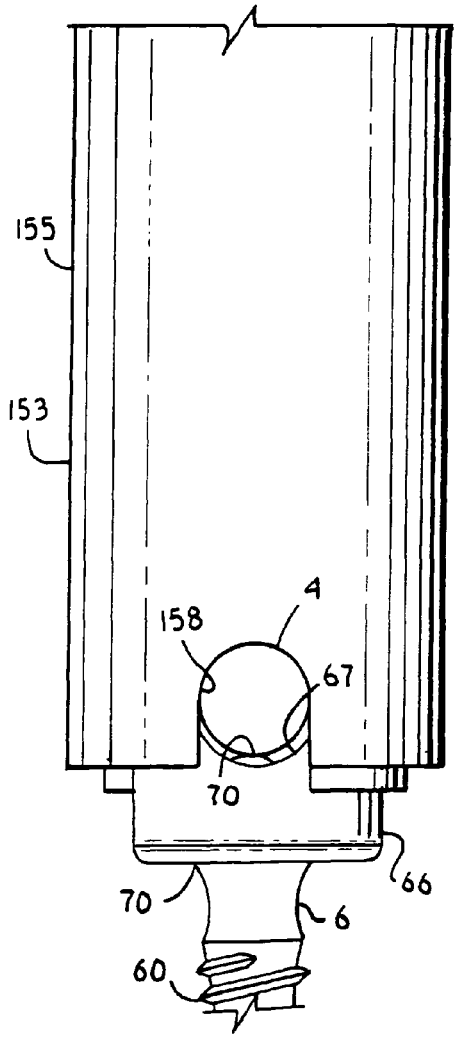


Fig.21.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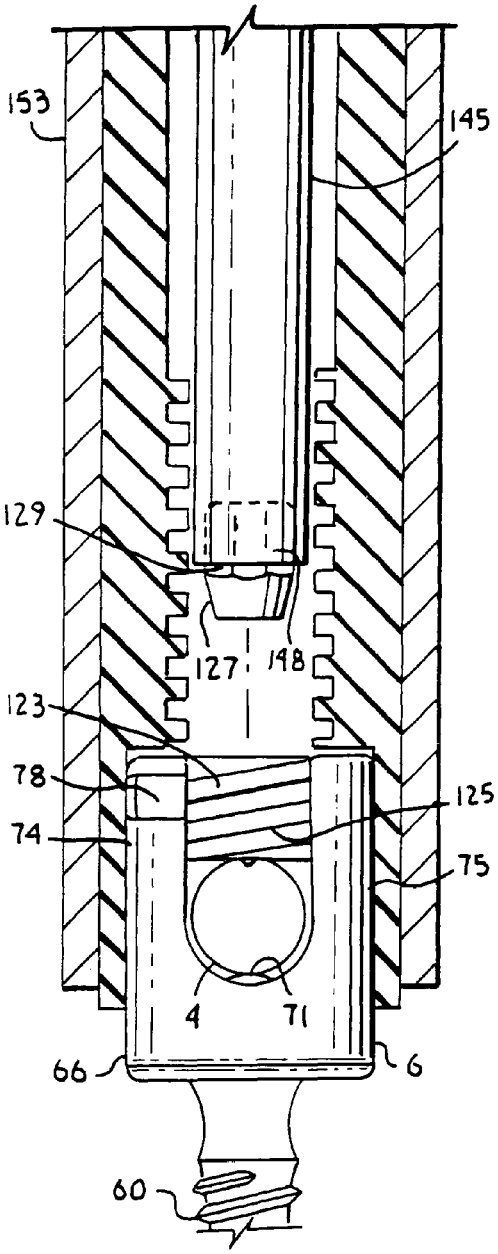
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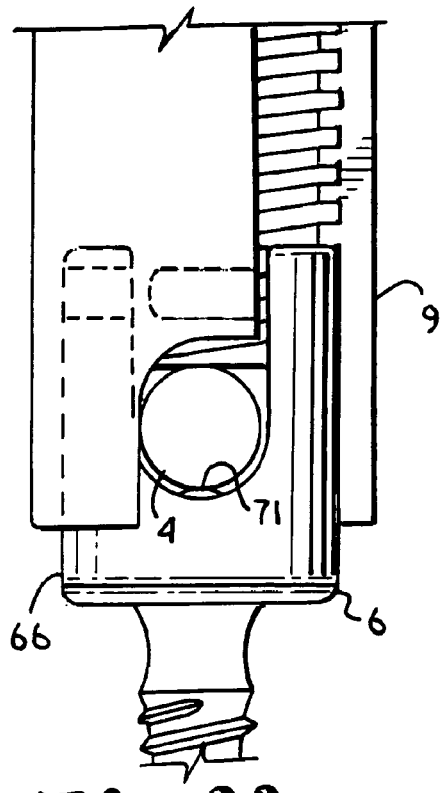

Fig.23.

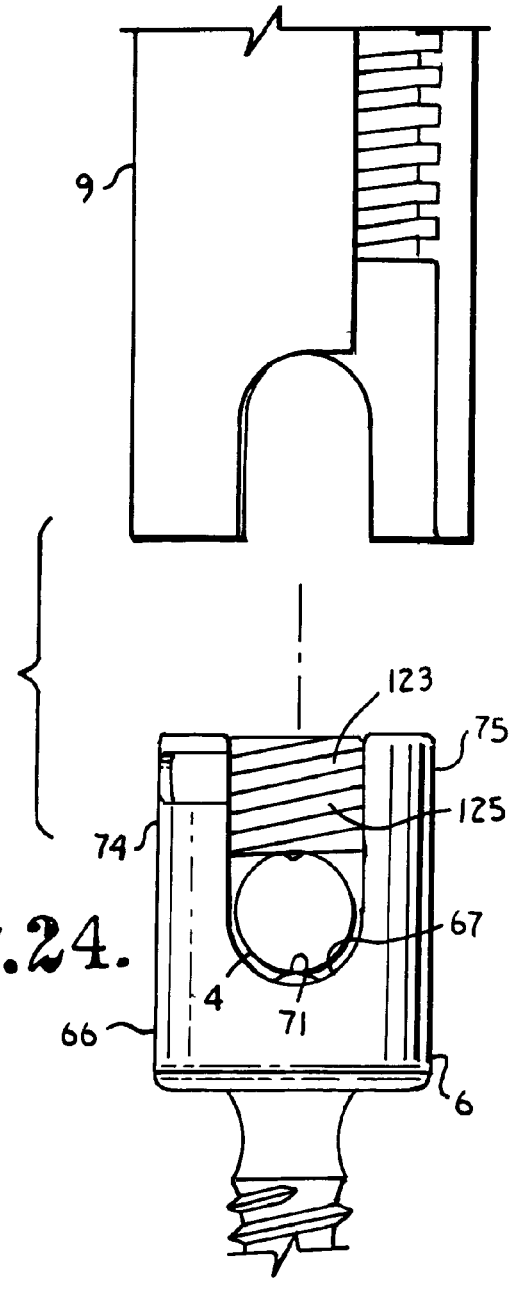

Fig.24.

METHOD FOR IMPLANTING AN ELONGATED IMPLANT ALONG A SPINE OF A PATIENT

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 13/573,660 filed Oct. 2, 2012, which application is a continuation of U.S. patent application Ser. No. 13/374,932, filed Jan. 24, 2012, now U.S. Pat. No. 8,377,067 dated Feb. 19, 2013, which is a continuation of U.S. patent application Ser. No. 12/584,413, filed Sep. 4, 2009, now U.S. Pat. No. 8,100,915 dated Jan. 24, 2012, which is a continuation of U.S. patent application Ser. No. 12/220,185, filed Jul. 22, 2008, now U.S. Pat. No. 8,162,948 dated Apr. 24, 2012, which is a division of U.S. patent application Ser. No. 10/789,149, filed Feb. 27, 2004, which issued as U.S. Pat. No. 7,160,300 on Jan. 9, 2007, all of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to apparatuses and methods for use in performing spinal surgery and, in particular, to tools and methods of using such tools, especially for percutaneously implanting a rod for spinal support and alignment using minimally invasive techniques.

For many years, spinal osteosynthesis apparatuses have been utilized to correct spinal deformities, injuries or disease. In such procedures, elongate rods are surgically attached to vertebrae of the spine to provide support and/or to reposition certain vertebrae. Such rods are secured to vertebrae utilizing bone screws and other implants.

Surgical techniques and bone screws have improved; however, in order to reduce the impact of such surgery on the patient, it has been desirable for such implants to be inserted percutaneously or with surgical techniques that are minimally invasive to the body of the patient. This presents a problem with implantation of rods that are elongate and have historically required a long incision and open wound in order to provide for the length of the rod and the space required for the surgeon's hands to manipulate the rod, implants and insertion tools used with the rod. Consequently, it has been desirable to develop apparatuses and techniques that allow for the insertion of bone screws, the insertion and reduction of a rod and the securing of the rod to the bone screws with significantly reduced invasion into the body of the patient and with minimal incision size in the skin over the operational site.

SUMMARY OF THE INVENTION

A set of tools is provided for percutaneously implanting a spinal rod in a patient. The tools include a pair of end guide tools that have channels sized to receive opposite ends of such a rod and allow sliding of the rod along the channel so as to guide ends of the rod into opposed end bone screw-heads to which the end guide tools are attached. Intermediate guide tools are also attached to bone screw-heads between the end bone screws and are slotted to guide the rod to respective bone screws attached to the intermediate guide tools.

The guide tools also include lower attachment structure to allow the guide tools to be easily and quickly secured to mating structure on a respective bone screw-head, and to be easily removed from the bone screw by manual rotation of a handle of the tools exterior of the patient, after which the guide tool is withdrawn from the patient. The intermediate guide tools have a snap-on and twist-off association with an associated intermediate bone screw and the end guide tools have a twist-on and twist-off association with respective end bone screws. In certain embodiments, other attachment structure may be used.

Each of the guide tools also includes an internal first lower guide and advancement structure that functions in cooperation with an internal second guide and advancement structure within the bone screw head and also with external helical wound thread or locking flange form mating structure on a bone screw closure top for closing the head of the bone screw, so as to be able to load the closure top though a top-to-bottom passageway in the guide tool and rotate the closure top with a closure top installation tool. Beneath the surface of the skin, the closure top is partially surrounded by the guide tool as it is directed to the bone screw. Clockwise rotation of the closure top in the region of the lower guide and advancement structure engages the closure top therewith and produces mechanical advantage that causes the closure top to be driven against the rod as it advances thereby urging the rod into the head of a respective bone screw. The closure top is driven and advanced by rotation of the closure top by the closure top installation tool and transferred or passed from the first guide and advancement structure in the guide tool to the second guide and advancement structure in the bone screw without losing mechanical advantage and while continually applying downward pressure on the rod, so as to drive the closure top downward and against the rod and so as to bias the rod into the head of the bone screw where it is captured by the closure top and locked in position.

OBJECTS AND ADVANTAGES OF THE INVENTION

Therefore, the objects of the present invention are: to provide a set of tools for implanting a spinal rod for support or alignment along a human spine with minimal surgical invasion of the patient; to provide such a set of tools including a pair of end tool guides for slidably guiding opposed ends of the rod toward end bone screws attached to the end guide tools; to provide such a set of tools including intermediate guide tools for each intermediate bone screw that guide the rod in slots therethrough to respective bone screws; to provide such a set of tools including rod pusher and closure top installation tools for assisting in securing the rod in the bone screws; to provide such a set of tools where the end guide tools include a longitudinal channel extending upwardly from near a bottom thereof to slidingly receive and guide ends of the rod toward associated end bone screws; to provide such a set of tools wherein the guide tools are easily attached to and disengaged from the bone screws; to provide such a set of tools wherein each guide tool includes a first guide and advancement structure near the bottom thereof that receives thread or locking flange mating structure on the closure top and advances the closure top upon rotation of the closure top to urge the rod downwardly; to provide such a set of tools wherein the guide tool first guide and advancement structure acts cooperatively with a second guide and advancement structure on the bone screw so as to transfer the closure top upon rotation thereof from the guide tool to the bone screw while continuously applying pressure to the rod and thereafter further advance the closure top to urge the rod into a seated position in the bone screw; to provide such a set of tools wherein the guide tools easily attach to and disengage from the bone screws by manual manipulation of the surgeon outside the patient's skin; to provide a method of implanting a rod into a patient with minimal surgical invasion of the

patient; to provide such a method utilizing the previously described tools for percutaneous implantation of such a rod; to provide such a method wherein end guide tools are utilized to receive opposite ends of a rod and guide the rod ends in the guide tool channels through manipulation of the guide tools and use of rod pusher tools; to provide such a method wherein intermediate guide tools are utilized to guide intermediate locations along the rod to respective intermediate bone screws; to provide such a method wherein guide and advancement structure near the bottoms of the guide tools, on the bone screws and on the closure tops are utilized to pass the closure top under rotation and with driving force between the guide tools and the bone screws and to drive the rod into a seating position in the bone screw; and to provide such a set of tools and methods that are easy to use and especially adapted for the intended use thereof and wherein the tools are comparatively inexpensive to produce.

Other objects and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings wherein are set forth, by way of illustration and example, certain embodiments of this invention.

The drawings constitute a part of this specification and include exemplary embodiments of the present invention and illustrate various objects and features thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a fragmentary front elevational view of an intermediate guide tool in accordance with the present invention.

FIG. **2** is a fragmentary side elevational view of the intermediate guide tool.

FIG. **3** is a fragmentary cross sectional view of the intermediate guide tool, taken along line **3-3** of FIG. **1**.

FIG. **4** is a fragmentary front elevational view of an end guide tool.

FIG. **5** is a fragmentary side elevational view of the end guide tool.

FIG. **6** is a cross sectional view of the end guide tool, taken along line **6-6** of FIG. **4**.

FIG. **7** is an enlarged and fragmentary front elevational view showing snap-on installation of the intermediate guide tool on a polyaxial bone screw head.

FIG. **8** is an enlarged and fragmentary front elevational view showing the intermediate guide tool installed on the bone screw head.

FIG. **9** is a fragmentary and cross-sectional view showing an early stage of the snap on installation of the intermediate guide tool on the bone screw head.

FIG. **10** is a fragmentary and cross-sectional view showing a later stage of installation of the intermediate guide tool on the bone screw head.

FIG. **11** is a fragmentary and cross-sectional view showing the intermediate guide tool installed on the bone screw head.

FIG. **12** is a partial and generally schematic view of a patient's spine with the end guide tool in conjunction with a bone screw installation tool, at the end of a process of installing a bone screw with attached end guide tool in a spinal vertebra.

FIG. **13** is a partial and generally schematic view of the spine with a pair of end guide tools and a pair of intermediate guide tools mounted on respective implanted bone screws and being utilized in an early stage of rod implantation to guide the rod toward the bone screws.

FIG. **14** is a view similar to FIG. **13** showing an intermediate stage of guiding the rod toward the bone screws.

FIG. **15** is a view similar to FIG. **13** showing a later intermediate stage of guiding the rod toward the bone screws.

FIG. **16** is a partial and generally schematic cross sectional view of the spine showing rods being implanted on opposite sides of the spine and with the rod on the left in an early stage of implanting while the rod on the right is in a later stage of implanting, taken along line **16-16** of FIG. **15**.

FIG. **17** is a cross-sectional view of an end guide tool, similar to FIG. **6**, shown during installation of the rod and a closure top in the bone screw attached to the end guide tool.

FIG. **18** is a view similar to FIG. **17** showing the rod and closure top installed in the bone screw before final torquing of the closure top.

FIG. **19** is a partial and generally schematic side view of the spine showing the rod fully installed in the bone screws.

FIG. **20** is an exploded and front elevational view of a closure top installation tool, antitorque tool and one of the intermediate guide tools attached to a bone screw.

FIG. **21** is a fragmentary and front elevational view of the antitorque tool being positioned so as to allow final torquing to a closure top in the bone screw.

FIG. **22** is an enlarged and fragmentary side view of the end guide tool, as shown in FIG. **21**, in conjunction with the installation tool and antitorque tool with portions broken away to shown interior detail and with the closure top having just been installed and torqued in the bone screw so that a break away head of the closure top has been removed.

FIG. **23** is a fragmentary and enlarged front elevational view showing an early stage in the removal of the end guide tool from the bone screw wherein the tool has been rotated approximately ninety degrees relative to its axis to the shown removal configuration from the installation configuration, such as seen in FIG. **17**, thereof.

FIG. **24** is a fragmentary and enlarged front elevational view showing the end guide tool disengaged from the bone screw.

DETAILED DESCRIPTION OF THE INVENTION

As required, detailed embodiments of the present invention are disclosed herein; however, it is to be understood that the disclosed embodiments are merely exemplary of the invention, which may be embodied in various forms. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a basis for the claims and as a representative basis for teaching one skilled in the art to variously employ the present invention in virtually any appropriately detailed structure.

The reference numeral **1** generally designates a tool set for use in installing an orthopedic spinal rod **4** into a set of bone screws **6** in accordance with the present invention.

The tool set **1** of the illustrated embodiment includes a pair of end guide tools **9** and a plurality of intermediate guide tools **10**, which in the illustrated embodiment includes a pair of intermediate guide tools **10** on each side of a patient's spine **17**, but which can include none, one or many intermediate guide tools **10** depending upon the particular application, so that one intermediate guide tool **10** is used for each intermediate bone screw **6** to which the rod **4** is to be attached. The bone screws **6** are implanted in the patent's spine **17** and, in particular, in vertebrae **18** along the spine **17**. Rods **4** are often installed on both sides of the spine **17**, as seen in FIG. **16**, during the same procedure.

The end guide tool **9** is illustrated in FIGS. **4** through **6**. In particular, each end guide tool **9** has an elongate body **14** that is sized and shaped to be sufficiently long to extend from implanted bone screws **6** through an exterior of a patient's

skin **14** so as to provide an outwardly extending and upper handle portion **16** that allows and provides for gripping by a surgeon during procedures utilizing the tool set **1**. Each of the end guides **9** include an intermediate portion **19** and a lower portion **20** along the length thereof. Each end guide tool **9** has a back wall **21** joining a pair of side walls **22** and **23**.

More specifically, the upper portion **16** of each end guide tool **9** is generally channel shaped having a U-shaped cross-section, a C-shaped cross-section, a crescent shaped cross-section or the like in order to form an opening **24** that opens into and forms part of a channel **25** that opens radially to one side of the end guide tool **9** and defines the side to side opening **24** that is sufficiently wide to receive additional tools and/or a closure top, as will be discussed below. The intermediate portion **19** of each end guide also includes an outward facing channel **29** that has an opening **26** which is somewhat smaller than the opening **24** of the upper portion **16**, such that the channel **29** is sized and shaped to receive certain tools, as described below. Finally, the end guide lower portion **20** also includes a groove or channel **34** opening radially outward and having a side-to-side width or opening **35** that is approximately the same size as the opening **26**. The channel **34** has a rear web or wall **36** having a lower end **37**. All of the channels **25**, **29** and **34** communicate with one another and are aligned with one another so as to provide a continuous elongate interior passageway with an open side from near a top **38** to near a bottom **39** thereof. This passageway provides a continuous open path of non uniform cross-section radius from the top **38** to the bottom **39** thereof that is parallel to an elongate axis A of each end guide tool **9**. As will be discussed later, each end guide tool channel **34** is especially sized and shaped to slidingly receive a respective end **42** of the rod **4** therein.

Near the end guide bottom **39** is a cut out **45** wherein a portion of the back wall **21** of the channel **34** is removed in order to provide a region having a size and shape to allow passage of a respective end **42** of the rod **4** therethrough. Also located near the end guide bottom **39** is a rod abutment recess **49** that is sized and shaped for the purpose of bridging the rod **4** when the end guide tool **9** is rotated for removal, as described below. The end guide tool **9** also receives a closure top **52**, as will be described below. Still further, near the bottom **39** of each of the end guides **9** is a helical wound first guide and advancement structure **50** which may include conventional helical threads, helically wound square threads, or other guide and advancement structure to cooperate with equivalent or mateable structure within the bone screw heads **6** and on the closure top **52**, as also described below. The lower free ends of the side walls **22** and **23** form spaced tangs or legs **53** and **54**.

At the bottom **39** of each end guide tool **9** is a radially inward facing attachment structure **55** that includes a base **56** and an upperly and axially extending projection, flange or hook member **57** which will be described in conjunction with a bone screw **6** below.

Referring more specifically to the bone screw **6**, each of the bone screws **6** includes a threaded shank **60** for screwing into and seating in a vertebra **18** that is part of the human spine **17**, see FIG. **12**. Each of the bone screws **6** also include a head **66** with a rod receiving channel **67** passing therethrough. Each of the bone screw shanks **60** includes an upper portion **70** that extends into the head **66** and is operationally secured therein, so that the head **66** is rotatable on the shank **60** until locked in position through engagement with the rod **4** under pressure. In particular, each shank upper portion **70** has an upwardly extending dome **71** that engages the rod **4**, when the rod **4** is placed within an associated channel **67** so that as the rod **4** urges the dome **71** downwardly, the shank upper portion **70** frictionally locks the shank **60** in position in a fixed angular position relative to the head **66**. Many different conventional bone screws where the head locks relative to the shank are well known in the art.

The present invention is not intended to be restricted to a particular type of bone screw. In the present embodiment, a polyaxial type bone screw **6** is utilized wherein the shank **60** is locked in position by direct contact with the rod **4**. It is foreseen that tool set **1** of the present invention can be used with virtually any type of bone screw, including polyaxial bone screws of many different types wherein the head is locked relative to the shank by structure other than in the manner described in the illustrated embodiment.

Each bone screw head **66** has a pair of upstanding arms **74** and **75** with internal second guide and advancement structure **76** on the insides thereof. One of the arms **74** includes a circumferentionally located receiver **78** that comprises a lower slot **79** that extends partially circumferentially about the periphery of the arm **74** and ends in an upperwardly projecting but hidden recess **80**. While the slot **79** is located on the arm **74** in the illustrated embodiment, a slot for this purpose could be located anywhere on the bone screw head **66**. The slot **79** and recess **80** are sized, shaped and positioned so as to receive the attachment structure **55** of the end guides **9** therein. For greater detail, see the description below for the attachment structure associated with intermediate guide tools **10** and shown in FIGS. **10** and **11**. The guide tool attachment structure **55** is sized and shaped to allow the attachment structure **55** to be received in the receiver **78** and locked therein by pulling the end guide tool **9** slightly axially upward relative to a respective bone screw **6**. In order to disengage the guide tool **9** from the bone screw **6**, the guide tool **9** is rotated **90** degrees counterclockwise from an attaching configuration, when viewing from the top so as to disengage the hook **57** from the recess **80** and so that the base **56** and hook **57** of the attachment structure **55** free to rotate above the rod **4** and closure top **52** and be released from the receiver **78**. In this manner, end guide tools **9** twist off of respective bone screws **6** and in the particular illustrated embodiment the end guide tools **9** are also assembled on the bone screws **6** by the opposite twist on maneuver is the reverse of the twist off maneuver. In certain embodiments where there is enough flexibility in the legs **53** and **54**, such that the legs **53** and **54** can be splayed radially outwardly at the bottom **39** thereof in the manner shown in FIG. **7**, so the end guide tool **9** snaps-on over the bone screw **6**, as will be described for the intermediate guide tools **10** below.

The unflexed space between the legs **53** and **54** that is equivalent to the width of the opening **35** is preferably substantially equivalent to the space between the bone screw arms **74** and **75** so that the channel **34** of the end guide tool **9** aligns with the channel **67** of the bone screw **6** when the end guide tool **9** is mounted on a respective bone screw **6**. The recess **49** is sized, shaped and positioned so that when the rod **4** is located in the bone screws **6**, the end guide tool **9** can rotate about axis A and the recess **49** allows the end guide tool **9** to straddle over the rod **4**, thereby allowing the end guide tool **9** to twist relative to the bone screw **6** and free the attachment structure **55** from the receiver **78** and thereafter be removed after all procedures are complete, as described below.

Each of the intermediate guide tools **10** (see especially FIGS. **1** to **3**) have a somewhat similar overall shape when compared to the end guide tools **9** in that both are preferably of the same axial length and width and also have much structure in common; however with certain differences as noted.

Many of the structures of the intermediate guide tools **10** that are the same as the end guide tools **9** are given the same reference number and the above noted description applies to each such tool **9** or **10**.

Each intermediate guide tool **10** has an overall elongate body **84** with an upper portion **86**, an intermediate portion **87** and a lower portion **88**. In the upper portion **86**, the body **84** is generally C-shaped having a radially outward opening and elongate and axially extending channel **90** terminating in a web or rear wall **91** with side walls **92** and **93**. The channel **90** has a front opening **95** that extends parallel to an axis of the body **84** and that is sized and shaped to receive tools and elements described below.

The intermediate portion **87** also includes an outwardly opening channel **97** with a rear web or wall **98** having a lower end **100** and a front opening **99** that is not as wide as the opening **95**. The lower portion **88** includes two spaced side walls or legs **93** and **94** with an elongate and axially extending passthrough opening **101** between the legs **93** and **94** that extends more than half way along the intermediate tool **10** and near the intermediate portion **87**. The legs **93** and **94** define between them a pass through and aligned slot **105** sized and shaped to slidingly receive the rod **6**.

The lower portion **88** extends substantially axially along the intermediate guide tools **10** and preferably to the location in use where the intermediate guide tools **10** pass through the skin **14**.

The bottom **39** of each intermediate guide tool **10** includes a helically wound but discontinuous square thread or first guide and advancement structure **109** that cooperates with the closure top **52**, as described below. The lower end of each intermediate guide tool **10** also includes a cutout **112** and an attachment structure **113** similar to structure **55** of the same type described for each end guide tool **9**.

The attachment structure **113** (see especially FIGS. **9** to **11**) includes a body **114** with an upperwardly extending, projection, flange or hook member **115** that follows the inner curvature of the guide tool leg **93**. The body **114** extends radially inward and is sized and shaped to mate with and set within the bone screw head receiver **78**. The bone screw receiver **78** is sufficiently wide to simultaneously receive both the body **114** and hook member **115** in a radially inward direction, as is shown in the view in FIG. **10**. The attachment structure **113** is then set by axially raising the guide tool **10** relative to the bone screw **6** so at least part of the hook member **115** is located in the recess **80** which secures the guide tool **10** (likewise guide tool **9**) to a respective bone screw **6**, as seen in FIG. **11**. This locks the guide tool **10** to a respective bone screw **6** and prevents outward splaying of the leg **93**. This is a snap-on type installation or assembly as seen in FIG. **7** where the leg **93** splays outward during initial placement of the guide tool **10** over the bone screw **6** and then returns to an unsplayed position when the attachment structure **113** seats in the receiver **78**, as shown in FIG. **10**. Alternatively, the guide tool **10** can be rotated approximately 90.degree. about its axis A prior to joining with a respective bone screw **6**, the attachment structure **113** lowered through the opening between the bone screw arms **74** and **75** and aligned with the bone screw receiver **78**, after which the guide tool **10** is rotated back to the first position shown in FIG. **11** in a twist on type assembly. In some instances the guide tool **10** is rotated somewhat more or less than ninety degrees to make the necessary alignment for removal which depends on the specific construction of the parts.

Enclosure **52** closes between the spaced bone screw arms **74** and **75** to secure the rod **4** in the channel **67**. The closure top **52** can be any of many different plug type closures. Preferably the closure top **52** has a cylindrical body **123** that has a helically wound mating guide and advancement structure **125**. The guide and advance at structure **125** can be of any type, including V-type threads, buttress threads, reverse angle threads, or square threads. Preferably the guide and advancement structure **125** is a helically wound flange form that interlocks with a reciprocal flange form as part of the second guide and advancement structure **76** on the interior of the bone screw arms **74** and **75**. A suitable locking guide and advancement structure of this type is disclosed in U.S. Pat. No. 6,726,689 from Ser. No. 10/236,123 which is incorporated herein by reference. The helical wound guide **50** and advancement structure in the bottom **39** of each of the guide tools **9** and **10** is sized and shaped to receive the mating guide and advancement structure **125** of the closure top **52** and align with the second guide and advancement structure **76** of the bone screw **6** to form a generally continuous helically wound pathway, but does not require locking between the closure top **52** and the tools **9** and **10**, even when a locking flange form is utilized on the closure top **52**. The illustrated structure **125** has a square form or a square thread type shape. The guide **50** allows the closure top **52** to be rotated and the surgeon to develop mechanical advantage to urge or drive the rod **4**, while still outside the bone screw head **6**, toward and into the bone screw head **66**. This is especially helpful where the rod **4** is bent relative to the location of the vertebra **18** to which the rod **4** is to attach and is not easily placed in the bone screw head **66** without force and the mechanical advantage provided by the guide **50**. In particular, the first guide and advancement structure **109** on each tool **9** and **10** is located and positioned to align with the second guide and advancement structure **76** on the insides of the bone screw arms **74** and **75**, as seen in FIGS. **17** and **18** and pass the closure top **52** therebetween while allowing the closure top **52** to continue to rotate and to continuously apply force to the rod **4**, so as to seat the rod **4** in the bone screw head **66**.

Each closure top **52** also preferably includes a break off head **127** that breaks from the body **123** in a break off region **128** upon the application of a preselected torque, such as 95 inch-pounds. The break off head preferably has a hexagonal cross section faceted exterior **129** that is adapted to mate with a similarly shaped socket of a closure driving or installation tool **145**, described below. It is foreseen that different driving heads or other methods of driving the closure top **52** can be utilize with certain embodiments of the invention.

Additional tools are utilized to assemble the implant. In particular, FIG. **16** illustrates a rod pusher **136** on the left. The pusher **136** has an elongate shaft or rod **138** that is preferably received in and passes through the interior of the guides **9** and **10**, such as the channel **90** of the guide tool **10**. The pusher **136** also has a tip **139** for engaging and urging the rod **4** downward, where there is minor resistance, and a handle **141**. It is foreseen that a pusher or gripper of the type that operates outside the guide tools **9** and **10** can be utilized, but is not preferred as such would normally require greater penetration of the skin **14** and more invasion of the patient.

Shown in FIG. **16** on the left and in FIG. **17** is the closure installation tool **145**. The tool **145** has an elongate rod or shaft **147** adapted to be received in and pass axially through any of the channels of the guides **9** and **10** and a handle **149**. The lower end of the rod **147** terminates in a socket **148** that is adapted to receive the closure break off head **127**, as shown in FIG. **17**.

Another tool used in implanting a rod **4** is an antitorque tool **153** which is seen in FIGS. **20** to **22**. The antitorque tool **153** is preferably used with the closure installation tool **145** to torque and set the closure top **52**, so it is snug against the rod

4, and thereafter break away the break off head **127** in the manner shown in FIG. **22**. The antitorque tool **153** includes a tubular hollow shaft **155** that is sized and shaped to be slidably received over the guide **9** and **10**. The antitorque tool **153** has a lower end **157** that has a pair of diametrically spaced bridges **158**. Each of the bridges **158** is sized and shaped to fit over the rod **4**, as seen in FIG. **21**. When in place, as seen in FIG. **21**, the antitorque tool **153** allows a surgeon to counter torque applied by the installation tool **145**, when applying torque to and breaking away the break off head **127**. The antitorque tool **153** also has an upper handle **16** with an opening through which the installation tool **145** passes in the manner suggested by the dashed lines in FIG. **20**.

In use, the previously described tools are utilized to attach one or more rods **4** to the human spinal column **17**.

The procedure is begun by forming a relatively small incision, such as incision **165** in the skin **14** for each bone screw **6** to be used. The incisions **165** are stretched into a round shape with a circumference equal to or just slightly larger than the guide tools **9** and **10**. The skin **14** is relatively flexible and allows the surgeon to move the incision **165** around relative to the spine **17** to manipulate the various tools and implants, as required. A drill (not shown) is utilized to form a guide bore (not shown) in a vertebra **18** under guidance of non invasive imaging techniques, which procedure is well known and established. A thin pin **166** is inserted in the guide bore. A bone screw **6** is selected in accordance with the size of the patient's vertebra **18** and the requirements of the spinal support needed. Bone screws **6** having a rotatable or poly axial head **66** are preferred for the procedure, as such allow relatively easy adjustment of the rod **4** in the tools **9** and **10** during placement and for movement of tools **9** and **10**, as described below. The bone screw **6** is also cannulated so as to be receivable over and guided by the pin **166** toward the proper position in the associated vertebra **18**.

Before placing the bone screw **6** in the vertebra **18**, the bone screw **6** is preferably joined to an associated guide tool **9** or **10**. This could be done after insertion of the bone screw **6**, but it is preferred to assemble both before inserting the bone screw **6**. With respect to the intermediate guide tool **10**, the lower end of the guide tool **10** is splayed or expanded outwardly by forcing the bone screw head **66** between the legs **93** and **94**, in the manner shown in FIG. **7** until the attachment structure **113** aligns with the receiver **78** and the former snaps into the later, as shown in FIG. **8**. Axial upward movement of the guide tool **10** relative to the bone screw **6** then sets the attachment structure **113** in the recess **80** in the process that is illustrated between FIGS. **10** and **11**. Alternatively, the tool **10** can be axially rotated ninety degrees relative to the bone screw **6** and the attachment structure **113** aligned with the recess **80** and then rotated back. The placement of the guide tools **9** on the associated bone screws **6** normally follows the later twist on procedure, as the structure of the guide tools **9** allow less flexing because of the longer back wall **21**. With tool **9**, the attachment structure **55** is placed in a respective receiver **55**.

A series of bone screws **6** are installed in each vertebra **18** to be attached to the rod **4** by use of a screwdriver or installation tool **135**, see FIG. **12**, that has a head, designed to grip the particular bone screw **6** used and which is also cannulated to receive the pin **166**. For each bone screw **6**, an associated guide tool **9** or **10** extends through the skin **14**, as seen in FIG. **13**. An end guide tool **9** is located at each end of the series of bone screws **6** and an intermediate guide tool **10** is located on each, intermediate bone screw **6**. The end guide tools **9** are turned or rotated so the channels **34** therein face one another and the intermediate guide tools **10** are aligned so slots **105** align with the channels **34**.

The rod **4** is then inserted diagonally through one of the end skin incisions **165** in the manner shown in FIG. **13** so that a first rod end **42** passes through the slots **105** in any intermediate guide tools **10** and into the channel **34** of the opposed end guide tool **9**. Back muscle tissue separates easily here to allow the upper insertion of the rod **4** and can be further separated by finger separation or cutting through one of the incisions **165**, if required.

After initial insertion, the second end **42** of the rod **4** is positioned in the channel **34** of the end guide tool **9** that is located next to the insertion point of the rod **4**, as is seen in FIG. **14**.

Once the rod **4** is positioned in the guide tools **9** and **10**, a pusher tool **136** of the type shown in FIG. **16** is utilized to push the rod **4** in each guide tool **9** or **10** toward the bone screw **6** associated with the guide tool **9** or **10** until the rod **4** is in approximately the position seen in FIG. **15**. During this time, the end guide tools **9** can be manipulated to help movement of the rod **4** therealong and can especially have the tops thereof splayed outwardly relative to each other, as seen in FIG. **15**. Again, the flexibility of the skin **14** allows such manipulation. Once the rod **4** reaches the bottom **39** of the end guide tools **9**, the rod ends **42** encounter the cut outs **45** on either side of the rod **4** and pass therethrough. The rod **4** is sized to extend a little beyond each end bone screw **6** to ensure full capture and reduce likelihood of dislodgement. Because the channels **34** are slightly inward of the full outer length of the rod **4**, the channels **34** must be tilted outward somewhat as seen in FIG. **15** to allow the rod **4** to pass down the channels **34** or one end **42** must be driven downward before the other. When the rod **4** is at the bottom of the guide tools **9** and **10**, such as seen in FIG. **19**, the end guide tools **9** can be returned to a position that is appropriate for properly aligning the bone screw heads **6** relative to the rod **4** prior to tightening and torquing the closure tops **52**. Because the rod **4** is normally bent and/or the vertebrae **18** do not align properly, the rod **4** must normally be biased into the bone screw heads **6**. This is accomplished by using the closure installation tool **145** in the manner illustrated on the right hand side in FIG. **16** and in FIG. **17**.

In particular, the tool **145** has a socket **148** that grips the break off head **127** of the closure top **52**. The installation tool **145** with closure top **52** therein is placed in the elongate top to bottom channel associated with the guide tools **9** and **10** either by entry from the side such as into channel **25** through opening **26** in guide tool **9** or into channel **25** through the top end **38** of the guide tool **9**. The closure top **52** is then driven under manual control of the surgeon by use of the installation tool **145** toward the rod **4**. Near the bottom of the guide tools **9** and **10**, such as near the bottom **39** of end guide tool **9**, the closure top **52** engages the helical wound first guide and advancement structure **50** and the tool **145** and closure top **52** are rotated mate the closure top helical mating structure **125** with the first guide and advancement structure **50** so as to drive the closure top **52** downward against the rod **4** and to urge the rod **4** downward into the bone screw channel **67**. At the bottom of the guide tool **9** or **10**, the closure top mating structure **125** engages and begins to mate with the guide and advancement structure **76** on a respective bone screw **6** and continued rotation of the tool **145** drives the rod **4** downward and into engagement with the dome **71** of the bone screw shank **60**, so as to snug against and frictionally lock the shank **60** in position relative to the bone screw head **66**, see FIG. **18**.

Once all of the closure tops **52** are in final seating position in respective bone screws **6** and the surgeon is satisfied with

the position of all of the elements, such as is seen in FIG. **19**, the antitorque tool **153** is mounted over each guide tool **9** or **10**, as shown in FIG. **21** with the bridges **158** straddling the rod **4** to prevent rotation. The installation tool **145** is inserted in the associated guide tool **9** or **10** and engaged with the break off head **127**. By cooperative use of the tools **145** and **153** a preselected torque is manually applied to the break off head **127** and it breaks from the closure top body **123** in the manner shown in FIG. **22** and is removed along with the antitorque tool **153**.

The guide tools **9** and **10** are then each rotated ninety degrees to align the attachment structure, such as structures **55** and **113** with the opening between bone screw arms **74** and **75**, as shown in FIG. **23**, so that the recess **49** straddles the rod **4** to allow the attachment structure **55** or **113** to disengage from the receiver **78**. The guide tool **9** or **10** is then pulled axially upward away from the bone screw **6** and from the incision **165** in the skin **14**, after which the incision **165** is closed.

It is to be understood that while certain forms of the present invention have been illustrated and described herein, it is not to be limited to the specific forms or arrangement of parts described and shown.

The invention claimed is:

1. A method for implanting a rod implant along a spine of a patient back, the method comprising:

a) minimally invasively passing the rod implant distally through a first minimally invasive incision in the patient back by causing a first end of the rod implant to distally displace along a first central longitudinal channel of a first elongated guide tool minimally invasively extending through the first minimally invasive incision from a first connection of a distal region of the first elongated guide tool to a head of a first bone anchor at a proximal region of the first bone anchor, the first bone anchor implanted in a first vertebra of the spine, and the head comprising a first rod-receiving channel;

b) after the first end has minimally invasively passed through the first minimally invasive incision as recited in step a), exiting the first end from the first central longitudinal channel via a first longitudinally extending side slot of the first elongated guide tool and displacing the first end towards a second elongated guide tool along a trajectory diagonal to a longitudinal axis of the first elongated guide tool, the second elongated guide tool minimally invasively extending through a second minimally invasive incision from a second connection of a distal region of the second elongated guide tool to a head of a second bone anchor at a proximal region of the second bone anchor, the second bone anchor implanted in a second vertebra of the spine, and the head of the second bone anchor comprising a second rod-receiving channel;

c) entering the first end into a second central longitudinal channel of the second elongated guide tool via a second longitudinally extending side slot of the second elongated guide tool; and

d) causing the rod implant near the first end to enter the second rod-receiving channel and the implant rod near a second end of the rod implant opposite the first end to enter the first rod-receiving channel.

2. The method of claim **1**, wherein, in achieving the steps recited in step d), the first end projects through a third longitudinally extending side slot of the second elongated guide tool opposite the second side slot.

3. The method of claim **2**, wherein, further in achieving the steps recited in step d), the second end projects through a fourth longitudinally extending side slot of the first elongated guide tool opposite the first side slot.

4. The method of claim **3**, wherein the first and fourth longitudinally extending side slots comprise different lengths.

5. The method of claim **4**, wherein the first longitudinally extending side slot is longer than the fourth longitudinally extending side slot.

6. The method of claim **2**, wherein the second and third longitudinally extending side slots comprise different lengths.

7. The method of claim **6**, wherein the second longitudinally extending side slot is longer than the third longitudinally extending side slot.

8. The method of claim **1**, wherein the first connection is a result of spaced-apart opposed legs of the distal region of the first elongated guide tool splaying apart as the head of the first bone anchor is forced proximally between the spaced-apart opposed legs, a feature of at least one of the legs snapping into engagement with a groove defined in a radially outward cylindrical surface of the head of the first bone anchor.

9. The method of claim **8**, further comprising application of a force directed to proximally displace the spaced-apart opposed legs relative to the head of the first bone anchor once the feature is received in the groove.

10. The method of claim **9**, wherein the groove comprises a planar boundary perpendicular to a longitudinal center axis of the head of the first bone anchor and perpendicularly intersecting the radially outward cylindrical surface of the head of the first bone anchor, the planar boundary making complementary planar surface contact with the feature when the feature is received in the groove.

11. The method of claim **8**, further comprising application of a force directed to proximally displace the spaced-apart opposed legs relative to the head of the first bone anchor, thereby setting the feature in the groove in a manner that inhibits splaying apart of the spaced-apart opposed legs.

12. The method of claim **11**, wherein the groove comprises a recessed overhanging configuration at a proximal boundary of the groove, and the feature comprises a proximally pointing free extent that is received by the recessed overhanging configuration.

13. The method of claim **1**, further comprising delivering a threaded closure top into the first rod-receiving channel via a route extending along the first central longitudinal channel, and threading the threaded closure top into the first rod-receiving channel to secure the rod implant within the first rod-receiving channel.

14. The method of claim **13**, further comprising positioning a counter-torque tool about an outer circumference of the first elongated guide tool, the counter-torque tool being used to apply counter-torque when the threaded closure top is being threaded into the first rod-receiving channel.

15. The method of claim **1**, further comprising rotating the first elongated guide tool relative to the head of the first bone anchor to disconnect the first elongated guide tool from the head of the first bone anchor.

16. The method of claim **1**, wherein the first and fourth side slots are aligned with the first rod-receiving channel when the rod implant enters the first rod-receiving channel.

17. The method of claim **1**, wherein a width of the first side slot along a majority of a length of the first side slot is narrower than another width of the first side slot near a distal end of the first side slot.

18. The method of claim **1**, wherein, in achieving the steps recited in step d), an elongated member distally displaces along the first central longitudinal channel of the first elon-

gated guide tool to distally drive the rod implant from the first central longitudinal channel into the second rod-receiving channel.

19. The method of claim **18**, further comprising rotating a threaded nut about the longitudinal axis of the first elongated guide tool, wherein the threaded nut is threadably engaged with threads defined in an inner wall surface of the first central longitudinal channel of the first elongated guide tool.

20. The method of claim **1**, wherein step b) further comprises causing the first end to pass through a fifth longitudinally extending side slot of a third elongated guide tool and a sixth longitudinally extending side slot of the third elongated guide tool as the first end is displaced towards the second elongated guide tool from the first longitudinally extending side slot of the first elongated guide tool, the fifth and sixth longitudinally extending side slots opposite each other and the third elongated guide tool minimally invasively extending through a third minimally invasive incision from a third connection of a distal region of the third elongated guide tool to a head of a third bone anchor at a proximal region of the third bone anchor, the third bone anchor implanted in a third vertebra of the spine, and the head of the third bone anchor comprising a third rod-receiving channel.

21. The method of claim **20**, wherein step d) further comprises causing the rod implant intermediate the first and second ends to enter the third rod-receiving channel.

22. The method of claim **20**, wherein the fifth and sixth longitudinally extending side slots comprise different lengths.

23. The method of claim **1**, wherein at least one of the first or second bone anchor comprises a bone screw.

24. The method of claim **23**, wherein the bone screw is at least one of polyaxial or cannulated.

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